RICOH

R1286K SERIES

2ch DCDC (Step Up DC/DC and Inverting DC/DC)

NO.EA-283-120228

OUTLINE

The R1286 2ch DC/DC converter is designed for AMOLED display power source. It contains a step up DC/DC converter and an inverting DC/DC converter.

Step up DC/DC converter generates boosted output voltage to 4.6V ~ 5.8V(Selectable). Inverting DC/DC converter generates negative voltage down to -2.0V ~ -6.0V(Selectable) that is dynamically adjustable with single wire interface signal. R1286 consist of a voltage reference, error amplifiers, an oscillator, PWM control circuits, over current protection circuits, short protection circuits, an under voltage lockout circuit (UVLO), thermal shutdown circuit, a NMOS driver and a synchronous PMOS switch for boost converter, a PMOS driver and a synchronous NMOS switch for inverting converter, and so on. High efficiency boost and inverting DC/DC converters can be composed with two external inductors and three capacitors.

FEATURES

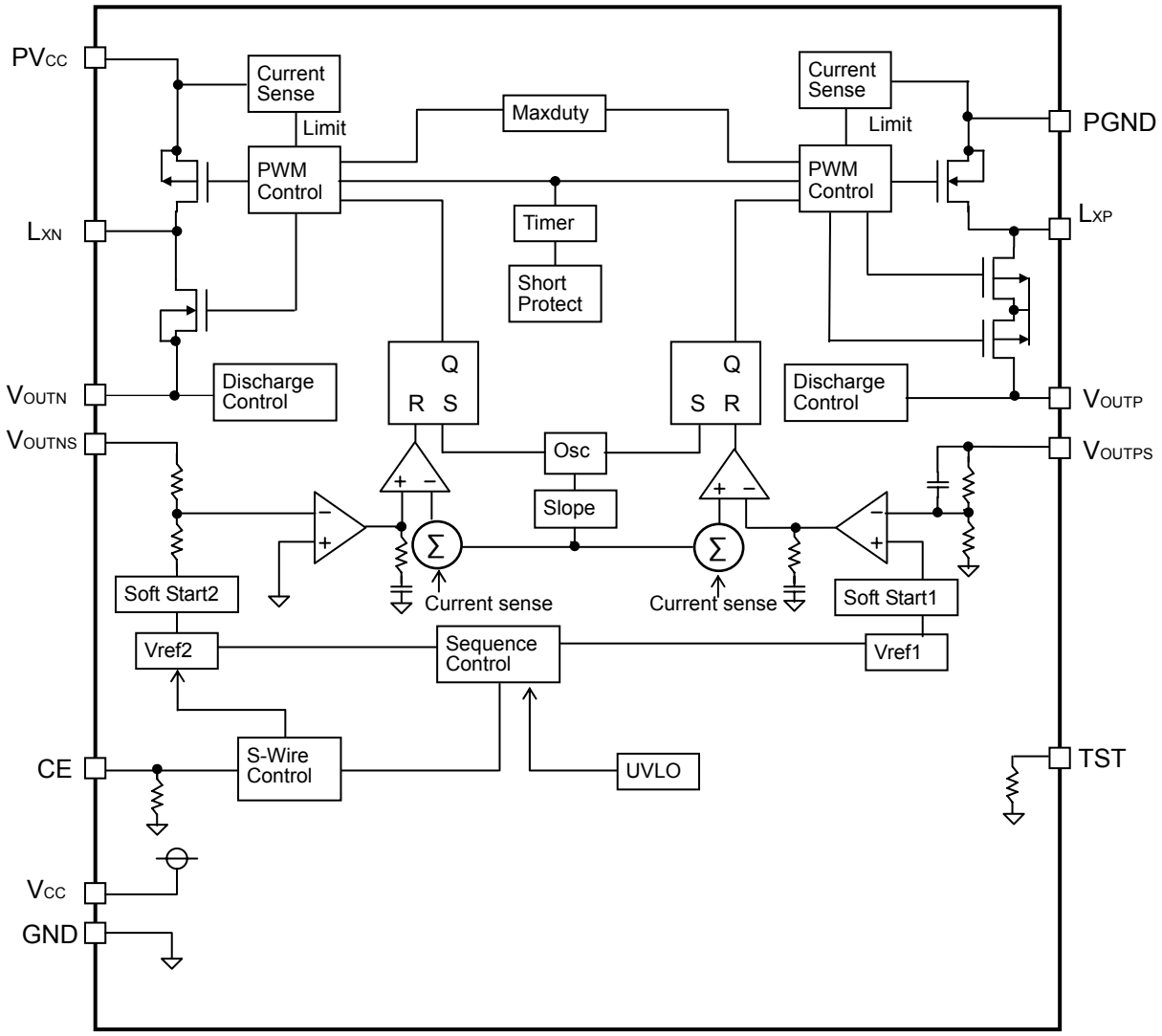
- Operating Voltage ..... 2.3V to 4.8V
- Step Up DC/DC (CH1)
  Output Voltage (V_{OUTP}) ..... 4.6V to 5.8V (Selectable / 0.1V Step) [R1286KxxxX]
  Adjustable V_{OUT} from 4.6V to 5.8V with external resistors [R1286K001B]
  Output Current (I_{OUTP})..... 250mA
- Inverting DC/DC (CH2)
  Dynamically adjustable Output Voltage (V_{OUTN}).....-2.0V to -6.0V (Range is fixed 3.0V / 0.1V Step)
  Single wire (S-Wire) interface (Default Value is Selectable / 0.1V Step) [R1286KxxxX]
  Adjustable V_{OUT} from -2.0V to -6.0V with external resistors [R1286K001B]
  Output Current (I_{OUTN})..... 250mA
- Control and Protection
  Internal start up sequence control with soft start operation
  Auto discharge operation for both outputs
  Over current protection and short circuit protection
  UVLO(Under voltage lock out) protection 2.05V
  Thermal shutdown ..... 150°C
  Operating frequency 1750kHz
  Maximum Duty Cycle ..... 85% for boost converter / 90% for inverting converter
- Package ..... DFN(PLP)2730-12

APPLICATION

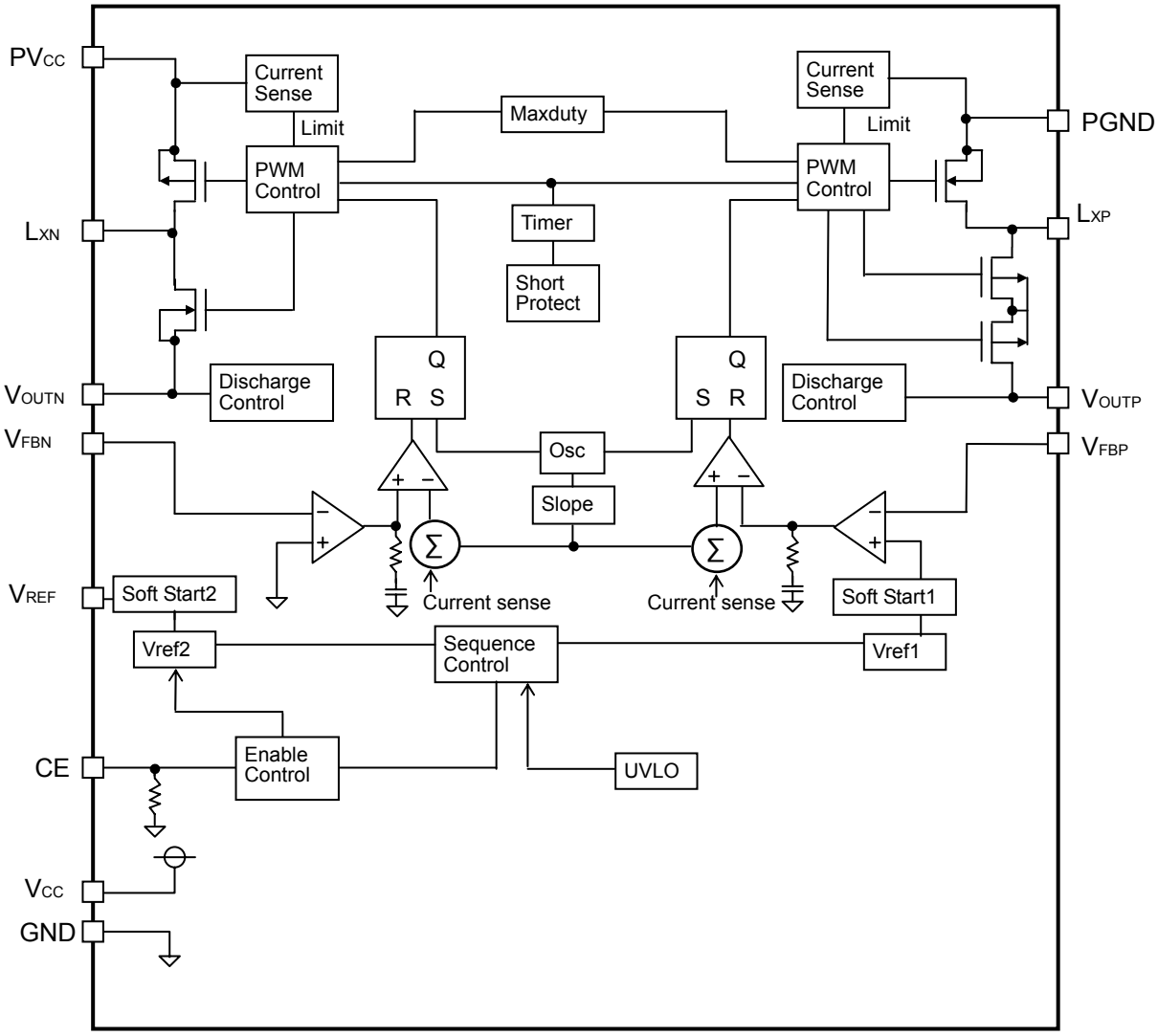
- Fixed voltage power supply for portable equipment
- Fixed voltage power supply for AMOLED, LCD

BLOCK DIAGRAM

●R1286KxxxA/C~G



●R1286K001B


PVCC
LXN
VOUTN
VFBN
VREF
CE
VCC
GND
PGND
LXP
VOUTP
VFBP
Current Sense
Limit
PWM Control
Maxduty
Timer
Short Protect
Discharge Control
Q
R S
S R
Osc
Slope
Current sense
Soft Start2
Soft Start1
Vref2
Vref1
Sequence Control
Enable Control
UVLO

SELECTION GUIDE

The inverting output voltage (V_{OUTN}), the positive output voltage (V_{OUTP}) and the versions of the inverting output voltage are user-selectable options.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1286Kxxx∗-TR	DFN(PLP)2730-12	5,000pcs	Yes	Yes

xxx: Output voltage (V_{OUTP} and V_{OUTN} default value) setting serial number
Further, refer to the voltage combination list(P.5).

∗ : Designation of method of setting Vout
(A/C~G) Dynamically adjustable output voltage version with S-Wire (V_{OUTN})
Fixed output version (V_{OUTP})
(B) Adjustable output voltage with external resistors version(V_{OUTP} & V_{OUTN})

∗	Designation of method of setting Vout	V_{ONDEF} *1)	V_{ONMIN}*1)	V_{ONMAX}*1)
A	Fixed and Dynamically adjustable output voltage version	-5.4~-2.4V	-5.4V	-2.4V
B	Adjustable output voltage with external resistors version	-	-	-
C	Fixed and Dynamically adjustable output voltage version	-5.0~-2.4V	-5.0V	-2.0V
D		-5.2~-2.4V	-5.2V	-2.2V
E		-5.6~-2.6V	-5.6V	-2.6V
F		-5.8~-2.8V	-5.8V	-2.8V
G		-6.0~-3.0V	-6.0V	-3.0V

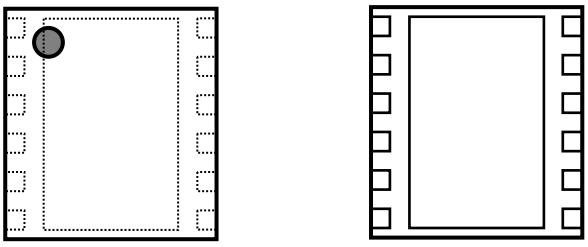
*1) V_{ONDEF} is V_{OUTN} default value. This voltage is fixed (Selectable / 0.1V Step).
V_{ONMIN} is V_{OUTN} minimum value with S-Wire.
V_{ONMAX} is V_{OUTN} maximum value with S-Wire.

・voltage combination list.

xxx	V_{OUTP}	V_{ONDEF}
001	External resistors	External resistors
002	4.6V	-4.9V
003	5.8V	-6.0V
004	4.8V	-4.9V
005	5.4V	-5.4V
006	5.0V	-5.0V
007	5.0V	-3.5V

PIN CONFIGURATION

● **DFN(PLP)2730-12**



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PIN DESCRIPTION

- **R1286KxxxA/C~G**

Pin No.	Symbol	Description
1	V_{OUTNS}	Feed Back Pin for Inverting DC/DC
2	V_{OUTN}	Outout Pin for Inverting DC/DC
3	L_{XN}	Switching Pin for Inverting DC/DC
4	PV_{CC}	Power Input Pin
5	V_{CC}	Analog Power Input Pin
6	GND	Analog GND Pin
7	PGND	Power GND Pin
8	L_{XP}	Switching Pin for Step up DC/DC
9	V_{OUTP}	Output Pin for Step up DC/DC
10	V_{OUTPS}	Feed Back Pin for Step up DC/DC
11	CE	Chip Enable and S-Wire Control Input Pin
12	TST	TEST Pin

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.

- **R1286K001B**

Pin No.	Symbol	Description
1	V_{FBN}	Feed Back Pin for Inverting DC/DC
2	V_{OUTN}	Outout Pin for Inverting DC/DC
3	L_{XN}	Switching Pin for Inverting DC/DC
4	PV_{CC}	Power Input Pin
5	V_{CC}	Analog Power Input Pin
6	GND	Analog GND Pin
7	PGND	Power GND Pin
8	L_{XP}	Switching Pin for Step up DC/DC
9	V_{OUTP}	Output Pin for Step up DC/DC
10	V_{FBP}	Feed Back Pin for Step up DC/DC
11	CE	Chip Enable Pin
12	V_{REF}	Reference Voltage Output Pin for Inverting DC/DC

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.

ABSOLUTE MAXIMUM RATINGS

(GND=PGND=0V)

Symbol	Item	Rating		Unit
V_{CC}	V_{CC} / PV_{CC} Pin Voltage	-0.3 to 6.0		V
V_{CE}	CE Pin Voltage	-0.3 to 6.0		V
V_{LXP}	L_{XP} Pin Voltage	-0.3 to 6.5		V
$V_{OUTP(S)}$	V_{OUTP} Pin Voltage	-0.3 to 6.5		V
V_{LXN}	L_{XN} Pin Voltage	V_{CC}-14 to V_{CC}+0.3		V
$V_{OUTN(S)}$	V_{OUTN} Pin Voltage	V_{CC}-14 to 0.3		V
V_{TST}	TST Pin Voltage [R1286KxxxX]	-0.3 to 6.0		V
V_{FBP}	V_{FBP} Pin Voltage [R1286K001B]	-0.3 to 6.0		V
V_{FBN}	V_{FBN} Pin Voltage [R1286K001B]	-0.3 to V_{CC}+0.3		V
V_{REF}	V_{REF} Pin Voltage [R1286K001B]	-0.3 to V_{CC}+0.3		V
P_D	Power Dissipation	Standard Land Pattern	1000*	mW
		High Wattage Land Pattern	1950*	mW
Ta	Operating Temperature Range	-40 to +85		ºC
Tstg	Storage Temperature Range	-55 to +125		ºC

.) For Power Dissipation, please refer to PACKAGE INFORMATION to be described.

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field.
The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

(Ta=25ºC)

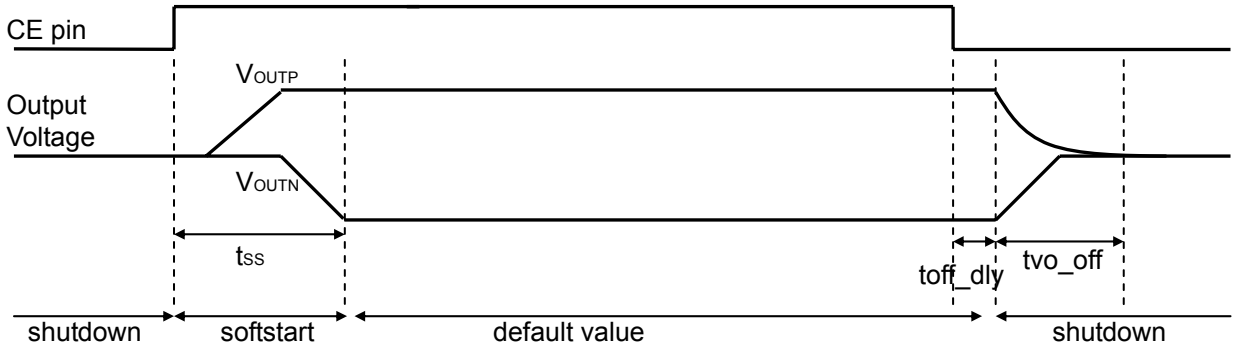
Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating Input Voltage		2.3		4.8	V
I_{CC}	V_{CC} Consumption Current (at no switching)	V_{CC}=4.8V		1.2		mA
Istandby	Standby Current	V_{CC}=V_{LXP}=4.8V , V_{CE}=V_{LXN}=0V		0.1	5	μA
V_{UVLO1}	UVLO Detect Voltage	Falling	1.95	2.05	2.15	V
V_{UVLO2}	UVLO Released Voltage	Rising		V_{UVLO1} +0.10	2.28	V
fosc	Oscillator Frequency	V_{CC}=3.7V	1500	1750	2000	kHz
t_{DLY}	Delay Time for Protection	V_{CC}=3.7V	8	16	24	ms
V_{CEH}	CE “H” Input Voltage	V_{CC}=4.8V	1.2			V
V_{CEL}	CE “L” Input Voltage	V_{CC}=2.3V			0.4	V
R_{CE}	CE pin Pull Down Resistance	V_{CC}=3.7V		160		kΩ
T_{TSD}	Thermal Shutdown Detect Temperature	V_{IN}=3.7V		150		°C
T_{TSR}	Thermal Shutdown Release Temperature	V_{IN}=3.7V		125		°C
■Boost DC/DC						
ΔV_{OUTP} /ΔI_{OUT}	V_{OUTP} Voltage Load Regulation	2.9V ≦ V_{CC} ≦ 4.2V, 10mA ≦ I_{OUT} ≦ 100mA		±5		mV
ΔV_{OUTP_TR}	V_{OUTP} Voltage Line Transient Response	V_{CC}=2.9V ↔ 3.4V, T_R=T_F=50μs I_{OUT}=100mA		±10		mV
Maxduty1	Maximum Duty Cycle	V_{CC}=3.7V		85		%
I_{LIMLXP}	L_{XP} Current Limit	V_{CC}=3.7V		1.0		A
I_{VOUTP}	V_{OUTP} Discharge Current	V_{CC}=3.7V, V_{OUTP}=0.1V		1.1		mA
t_{SSP}	V_{OUTP} Soft-Start Time	V_{CC}=3.7V	1.6	2.4	3.0	ms
R_{LXP}	L_{XP} ON Resistance	V_{CC}=3.7V		400		mΩ
R_{SYNCP}	Synchronous Sw ON Resistance	V_{CC}=3.7V		700		mΩ
[Version.A/C~G]						
V_{OUTP}	V_{OUTP} Voltage	V_{CC}=3.7V	×0.991	setting	×1.009	V
$V_{OUTP}/\Delta T$	V_{OUTP} Voltage Temperature Coefficient	V_{CC}=3.7V, -40°C ≦ Ta ≦ 85°C		±50		ppm /°C
[Version.B]						
V_{FBP}	V_{FBP} Voltage Tolerance	V_{CC}=3.7V	0.985	1.000	1.015	V
I_{FBP}	V_{FBP} Input Current	V_{CC}=4.8V, V_{FBP}=0V or 4.8V	-0.1		0.1	μA
$\Delta V_{FBP}/\Delta T$	V_{FBP} Voltage Temperature Coefficient	V_{CC}=3.7V, -40°C ≦ Ta ≦ 85°C		±50		ppm /°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
■Inverting DC/DC						
ΔV_{OUTN} /ΔI_{OUT}	V_{OUTN} Voltage Load Regulation	2.9V ≦ V_{CC} ≦ 4.2V, 10mA ≦ I_{OUT} ≦ 100mA		±5		mV
ΔV_{OUTN_TR}	V_{OUTN} Voltage Line Transient Response	V_{CC}=2.9V ↔ 3.4V, T_R=T_F=50μs I_{OUT}=100mA		±15		mV
Maxduty2	Maximum Duty Cycle	V_{CC}=3.7V		90		%
I_{LIMLXN}	L_{XN} Current Limit	V_{CC}=3.7V		1.5		A
I_{VOUTN}	V_{OUTN} Discharge Current	V_{CC}=3.7V, V_{OUTN}=-0.1		0.3		mA
R_{LXN}	L_{XN} ON Resistance	V_{CC}=3.7V		400		mΩ
R_{SYNCN}	Synchronous Sw ON Resistance	V_{CC}=3.7V		600		mΩ
[Version. A/C~G]						
V_{ONDEF}	V_{OUTN} Default Voltage	V_{CC}=3.7V, selectable between V_{ONMIN} and V_{ONMAX}	setting -70	setting	setting +70	mV
V_{ONMIN}	V_{OUTN} Minimum Voltage	V_{CC}=3.7V, selectable between -2.0V and -3.0V	setting -70	setting	setting +70	mV
V_{ONMAX}	V_{OUTN} Maximum Voltage	V_{CC}=3.7V	setting -70	V_{ONMIN} + 3.0V	setting +70	mV
V_{OUTN}	V_{OUTN} Voltage with S-Wire	V_{CC}=3.7V(guaranteed by design engineering)	setting -80	setting	setting +80	mV
ΔV_{OUTN} /ΔT	V_{OUTN} Voltage Temperature Coefficient	V_{CC}=3.7V, -40°C ≦ Ta ≦ 85°C		±50		ppm /°C
t_{SSN}	V_{OUTN} Soft-Start Time	V_{CC}=3.7V	1.6x V_{ONDEF}/ -4.9	2.3x V_{ONDEF} /-4.9	3.0x V_{ONDEF}/ -4.9	ms
[Version.B]						
V_{FBN}	V_{FBN} Voltage Tolerance	V_{CC}=3.7V	-25	0	25	mV
V_{REF}	V_{REF} Voltage Tolerance	V_{CC}=3.7V	1.18 +V_{FBN}	1.2 +V_{FBN}	1.22 +V_{FBN}	V
I_{FBN}	V_{FBN} Input Current	V_{CC}=4.8V, V_{FBN}=0V or 4.8V	-0.1		0.1	μA
ΔV_{REF} /ΔT	V_{REF} Voltage Temperature Coefficient	V_{CC}=3.7V, -40°C ≦ Ta ≦ 85°C		±50		ppm /°C
t_{SSN}	V_{OUTN} Soft-Start Time	V_{CC}=3.7V	1.6	2.8	3.6	ms

∗1) In terms of TST pin, connect the GND level or remain it open.

TIMING CHART

- **SEQUENCE with S-Wire control for V_{OUTN}(R1286KxxxA/C~G)**



・Softstart

V_{OUTP} rises up first and secondarily V_{OUTN} goes down.
Soft start time(t_{SS}) = 2.4ms + 2.3ms x V_{ONDEF}/-4.9(Typ.)
In this time V_{OUTN} is set V_{ONDEF}.

・Shutdown

If the CE pin input is "L" in the fixed time (toff_dly : Max.110μsec), the IC becomes the standby mode and switching of the outputs of L_{XP} and L_{XN} will stop.
Discharge time(tvo_off) = 2.0ms(Cout = 4.7uF : Typ.)

・S-Wire control for V_{OUTN}

After receiving the S-Wire control command, V_{OUTN} is changed to the target voltage.
When R1286 is used at V_{ONDEF} voltage, please don't input short 'L' pulse(1μ ~ 110μsec) to CE pin.
To reset the S-Wire control command, please input 'L' pulse(more than 110μsec) to CE pin.

- **V_{OUTN} Variable Table**

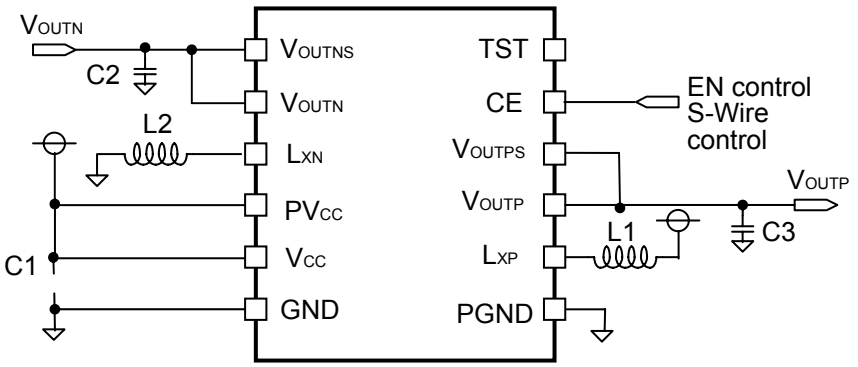
The adjusted value setting command are operated with S-Wire input (pulse count) that is shown in Table.1.

Table.1 V_{OUTN} Variable Table (31 steps)

BIT (pulse count)	V_{OUTN}	BIT (pulse count)	V_{OUTN}
0(default)	V_{ONDEF}	16	V_{ONMIN} – 1.5
1	V_{ONMIN}	17	V_{ONMIN} – 1.6
2	V_{ONMIN} – 0.1	18	V_{ONMIN} – 1.7
3	V_{ONMIN} – 0.2	19	V_{ONMIN} – 1.8
4	V_{ONMIN} – 0.3	20	V_{ONMIN} – 1.9
5	V_{ONMIN} – 0.4	21	V_{ONMIN} – 2.0
6	V_{ONMIN} – 0.5	22	V_{ONMIN} – 2.1
7	V_{ONMIN} – 0.6	23	V_{ONMIN} – 2.2
8	V_{ONMIN} – 0.7	24	V_{ONMIN} – 2.3
9	V_{ONMIN} – 0.8	25	V_{ONMIN} – 2.4
10	V_{ONMIN} – 0.9	26	V_{ONMIN} – 2.5
11	V_{ONMIN} – 1.0	27	V_{ONMIN} – 2.6
12	V_{ONMIN} – 1.1	28	V_{ONMIN} – 2.7
13	V_{ONMIN} – 1.2	29	V_{ONMIN} – 2.8
14	V_{ONMIN} – 1.3	30	V_{ONMIN} – 2.9
15	V_{ONMIN} – 1.4	31	V_{ONMIN} – 3.0

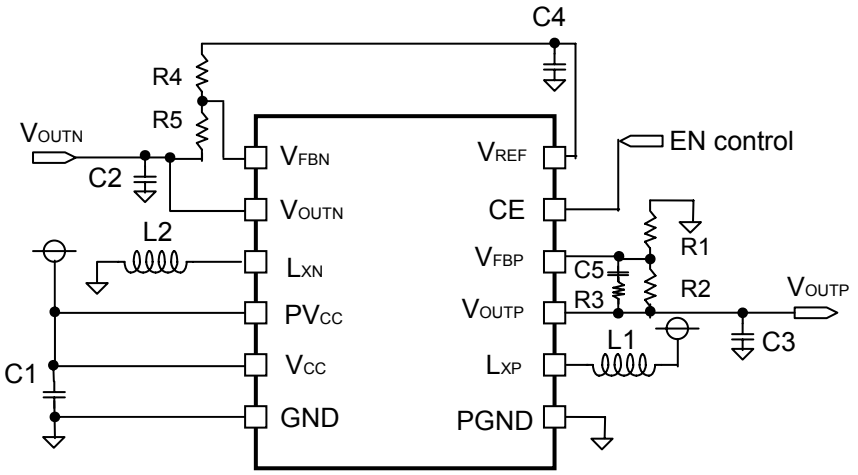
TECHNICAL NOTES

●R1286KxxxA/C~G



L1	VLF302510M-4R7M(TDK) VLF3010S-4R7M(TDK)
L2	VLF4012S-4R7M (TDK) NR4012T4R7M (TAIYOYUDEN)
C1	4.7μF 2012size X5R T=1.0max
C2	4.7μF 2012size X5R T=1.0max
C3	4.7μF 2012size X5R T=1.0max

●R1286K001B



L1	VLF302510M-4R7M(TDK) VLF3010S-4R7M(TDK)
L2	VLF4012S-4R7M (TDK) NR4012T4R7M (TAIYOYUDEN)
C1	4.7μF 2012size X5R T=1.0max
C2	4.7μF 2012size X5R T=1.0max
C3	4.7μF 2012size X5R T=1.0max
C4	0.1μF 0603size

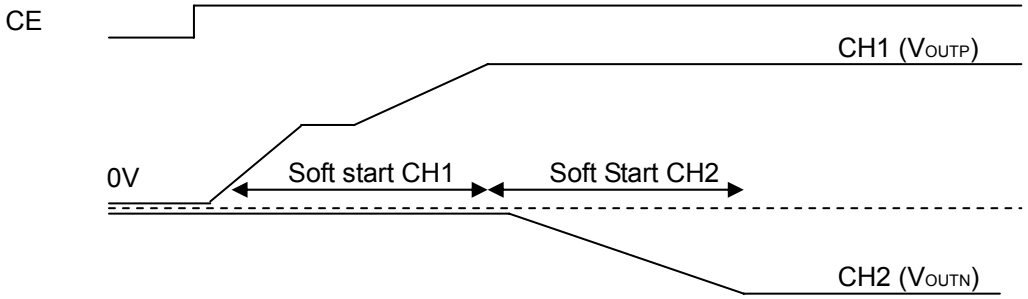
・Set a ceramic 4.7μF or more capacitor between V_{CC} and GND as C1.

・Set a ceramic 4.7μF or more capacitor between V_{OUTP} and GND, and between V_{OUTN} and GND for each as C2 and C3.

・Set a ceramic 0.1μF to 2.2μF capacitor between V_{REF} and GND as C4. [R1286K001B]

・**Start up Sequence**

When CE level turns from 'L' to 'H' level, the softstart of CH1 starts the operation. After detecting output voltage of CH1(V_{OUTP})as the nominal level, the soft start of CH2 starts the operation.



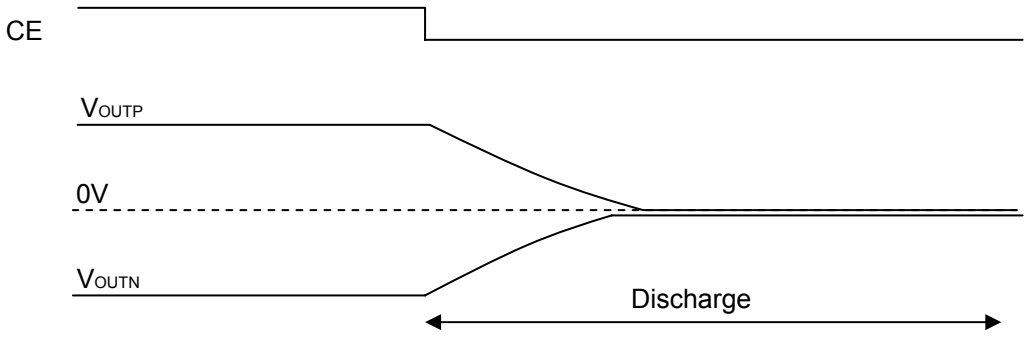
・**Auto Discharge Function**

When CE level turns from 'H' to 'L' level, the R1286 goes into standby mode and switching of the outputs of L_{XP} and L_{XN} will stop. Then dischage switsh between V_{OUTN} and GND and switch between V_{OUTP} and GND turn on and discharge the negative output voltage and positive output voltage.

The positive and negative output voltage is discharged to 0V in standby mode.

If Vcc voltage became lower than UVLO detect voltage , discharge switches also turn on and discharge output voltage(V_{OUTN} and V_{OUTP}) .

In case of timer latch protection,discharge switches will keep off .



・**Thermal Shutdown Protection**

If the over temparature is detected, internal Mosfet will turn-off soon. And when the temparature get lower than the release temparature, IC is reset and restart the operation.

· **Over Current Protection and Short Protection Circuit Timer**

The over current protection circuit supervises the peak current of the coil (The current passing through NMOS transistor of CH1 and PMOS transistor of CH2) with respect to each switching cycle. If the peak current exceeds the L_X current limit (I_{LIMLXP} or I_{LIMLXN}), the over current protection circuit turns off the NMOS transistor of CH1 or PMOS transistor of CH2.

If the over current continues more than the protection delay time (T_{DLY}), the short current protection circuit latches the built-in driver at OFF state and stops the operation of DC/DC converter.

∗ L_X limit current (I_{LIMLXP} or I_{LIMLXN}) and the protection delay time (T_{DLY}) can be easily affected by self-heating and ambient environment. The drastic drop of output voltage or the unstable output voltage caused by the short-circuiting may affect on the protection operation and the delay time.

To release the latch over current protection, reset the IC by inputting “L” into CE pin or by making the input voltage lower than the UVLO detector threshold (V_{UVL01}).

During the softstart operation of CH1 and CH2, the timer operates until detecting output voltage of CH2(V_{OUTN})as the nominal level . Therefore, even if the softstart cannot finish correctly because of the short circuit, the protection timer function will be able to work correctly.

· **Step-up DC/DC Converter Output Voltage Setting [R1286K001B]**

The output voltage V_{OUTP} of the step-up DC/DC converter is controlled with maintaining the V_{FBP} as 1.0V.
V_{OUTP} can be set with adjusting the values of R1 and R2 as in the next formula.

$$V_{OUTP} = V_{FBP} \times (R1 + R2) / R1$$

V_{OUTP} can be set from 4.6V to 5.8V. The appropriate value range of R1 is from 20kΩ to 60k Ω.

· **Inverting DC/DC Converter Output Voltage Setting [R1286K001B]**

The output voltage V_{OUTN} of the inverting DC/DC converter is controlled with maintaining the V_{FBN} as 0V.
V_{OUTN} can be set with adjusting the values of R1 and R2 as in the next formula.

$$V_{OUTN} = V_{FBN} - (V_{REF} - V_{FBN}) \times R5 / R4$$

V_{OUTN} can be set from -2.0V to -6.0V. The appropriate value range of R4 is from 2.5kΩ to 60kΩ.

· **Phase Compensation of Step-up DC/DC Converter [R1286K001B]**

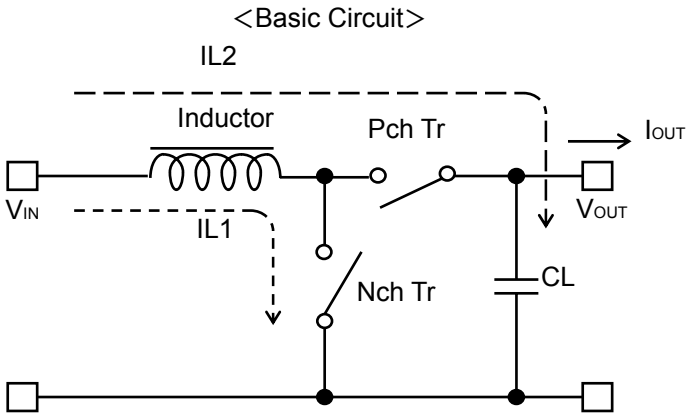
DC/DC converter’s phase may lose 180 degree by external components of L and C and load current. Because of this, the phase margin of the system will be less and the stability will be worse. Therefore, the phase must be gained.

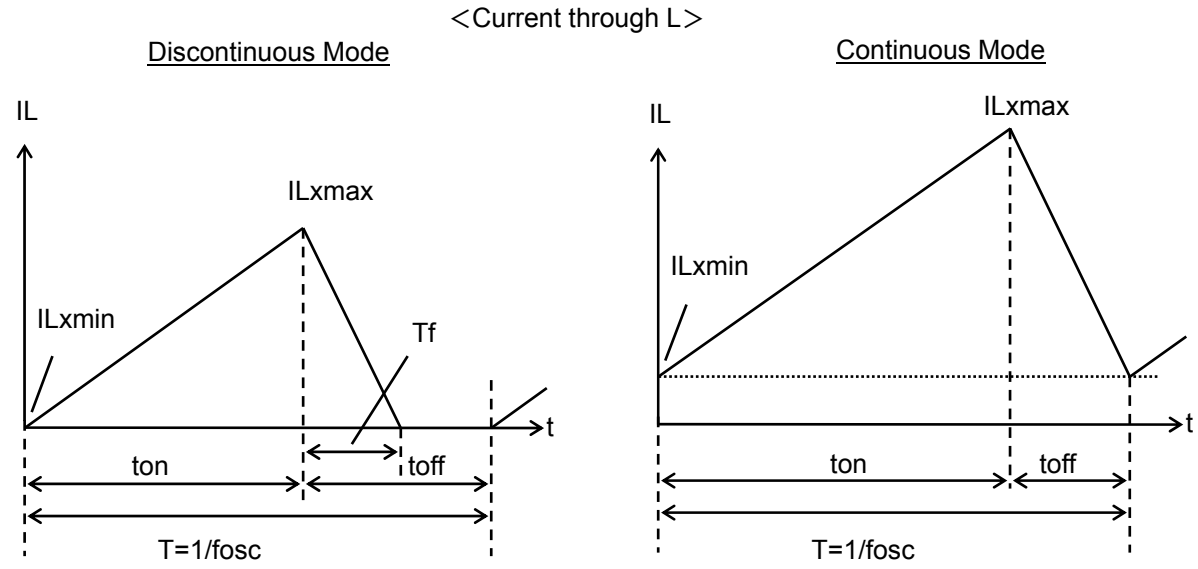
Zero will be formed with R1 and C5.

$$C5\ [pF] = 300 / R1[k\Omega]$$

If the noise of the system is large, the output noise affects the feedback and the operation may be unstable. In that case, another resistor R3 will be set. The appropriate value range is from 10Ω to 1kΩ.

Operation of Step-up DC/DC Converter and Output Current





There are two operation modes for the PWM control step-up switching regulator, that is the continuous mode and the discontinuous mode.

When the NMOS Tr. is on, the voltage for the inductor L will be VIN. The inductor current (IL1) will be;

$IL1 = V_{IN} \times t_{on} / L$ Formula1

When the NMOS Tr. turns off and PMOS Tr. is on. The inductor current (IL2) will be;

$IL2 = (V_{OUT} - V_{IN}) \times tf / L$ Formula2

In terms of the PWM control, when the $tf = t_{off}$, the inductor current will be continuous, the operation of the switching regulator will be continuous mode.

In the continuous mode, the current variation of IL1 and IL2 are same, therefore

$$V_{IN} \times t_{on} / L = (V_{OUT} - V_{IN}) \times t_{off} / L \quad \text{Formula3}$$

In the continuous mode, the duty cycle will be

$$DUTY = t_{on} / (t_{on} + t_{off}) = (V_{OUT} - V_{IN}) / V_{OUT} \quad \text{Formula4}$$

If the input power equals to output power,

$$I_{OUT} = V_{IN}^2 \times t_{on} / (2 \times L \times V_{OUT}) \quad \text{Formula5}$$

When I_{OUT} becomes more then Formula5, it will be continuous mode.

In this moment, the peak current, I_{Lxmax} flowing through the inductor is described as follows:

$$I_{Lxmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times t_{on} /(2 \times L) \quad \text{Formula6}$$

$$I_{Lxmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN}) /(2 \times L \times V_{OUT}) \quad \text{Formula7}$$

Therefore, peak current is more than I_{OUT}. Considering the value of I_{Lxmax}, the condition of input and output, and external components should be selected.

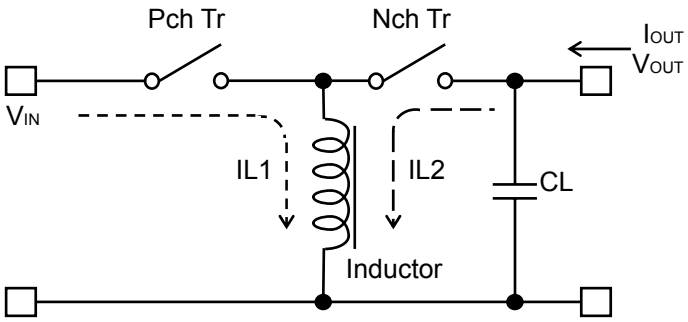
The explanation above is based on the ideal calculation, and the loss caused by Tr. and external components is not included.

The actual maximum output current is between 80% and 90% of the calculation.

Especially, when the IL is large, or V_{IN} is low, the loss of V_{IN} is generated with on resistance of the switch.

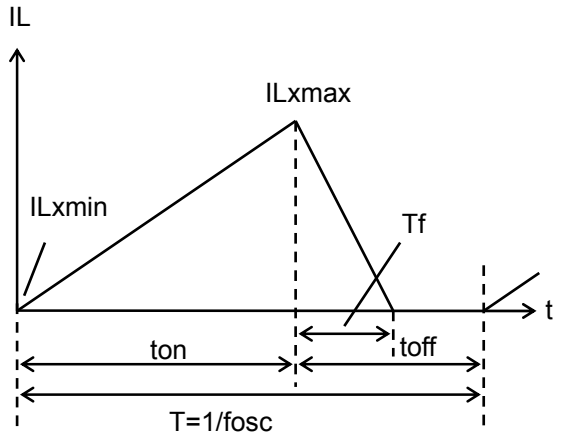
Operation of Inverting DC/DC Converter and Output Current

<Basic Circuit>

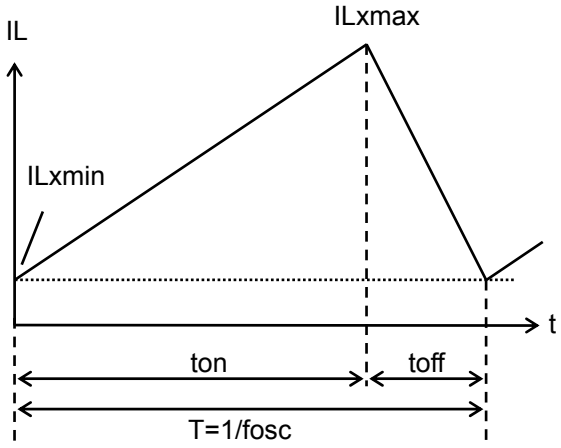


<Current through L>

Discontinuous Mode



Continuous Mode



There are also two operation modes for the PWM control inverting switching regulator, that is the continuous mode and the discontinuous mode.

When the L_X Tr. is on, the voltage for the inductor L will be V_{IN}. The inductor current (IL1) will be;

$$IL1 = V_{IN} \times t_{on} / L \quad \text{Formula8}$$

Inverting circuit saves energy during on time of Tr, and supplies the energy to output during off time, output voltage opposed to input voltage is obtained. The inductor current at off (IL2) will be;

$$IL2 = V_{OUT} \times Tf / L \quad \text{Formula9}$$

(The above formula and after, the absolute value of the negative output voltage is assumed to be V_{OUT}.: Output voltage= -6V, V_{OUT}=6)

In terms of the PWM control, when the Tf = t_{off}, the inductor current will be continuous, the operation of the switching regulator will be continuous mode.

In the continuous mode, the current variation of IL1 and IL2 are same, therefore

$$V_{IN} \times ton / L = V_{OUT} \times toff / L \quad \text{Formula10}$$

In the continuous mode, the duty cycle will be:

$$DUTY = ton / (ton + toff) = V_{OUT} / (V_{OUT} + V_{IN}) \quad \text{Formula11}$$

If the input power equals to output power,

$$I_{OUT} = V_{IN}^2 \times ton / (2 \times L \times V_{OUT}) \quad \text{Formula12}$$

When I_{OUT} becomes more then Formula12 , it will be continuous mode.

In this moment, the peak current, IL_{xmax} flowing through the inductor is described as follows:

$$IL_{xmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times ton / (2 \times L) \quad \text{Formula13}$$

$$IL_{xmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times V_{OUT} \times T / \{ 2 \times L \times (V_{OUT} + V_{IN}) \} \quad \text{Formula14}$$

Therefore, peak current is more than I_{OUT}. Considering the value of IL_{xmax}, the condition of input and output, and external components should be selected.

The explanation above is based on the ideal calculation, and the loss caused by Lx switch and external components is not included.

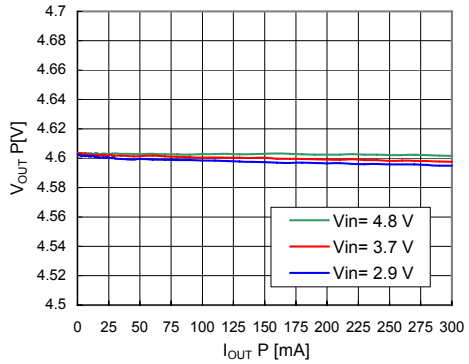
The actual maximum output current is between 70% and 90% of the calculation.

Especially, when the IL is large, or V_{IN} is low, the loss of V_{IN} is generated with on resistance of the switch.

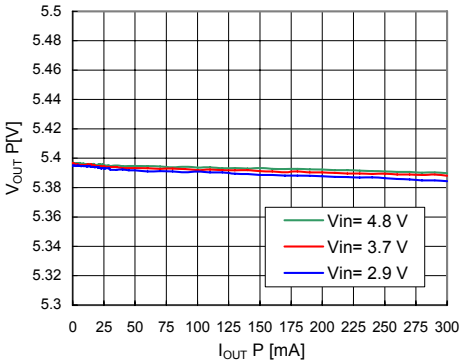
■R1286KxxxX Typical Characteristics

1) Output voltage vs. Output Current

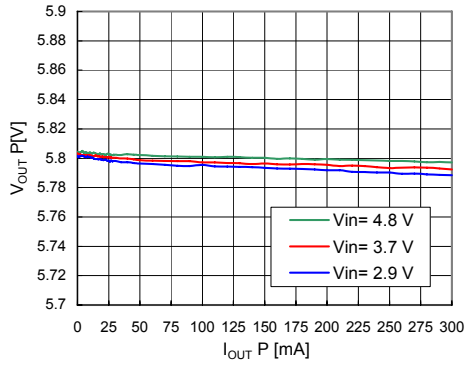
R1286KxxxX(V_{OUT}P= 4.6V)



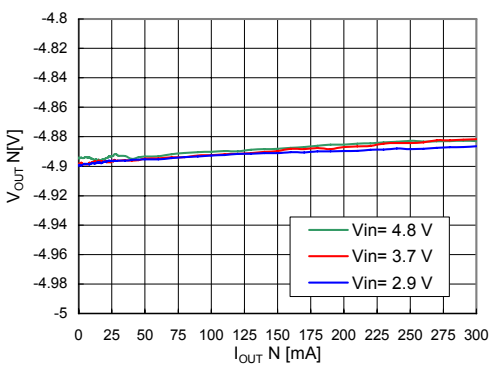
R1286KxxxX(V_{OUT}P= 5.4V)



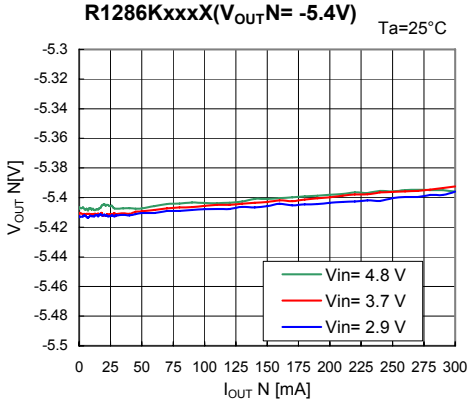
R1286KxxxX(V_{OUT}P= 5.8V)



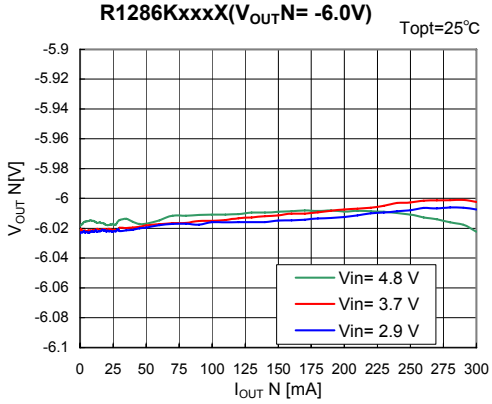
R1286KxxxX(V_{OUT}N= -4.9V)



R1286KxxxX(V_{OUT}N= -5.4V)

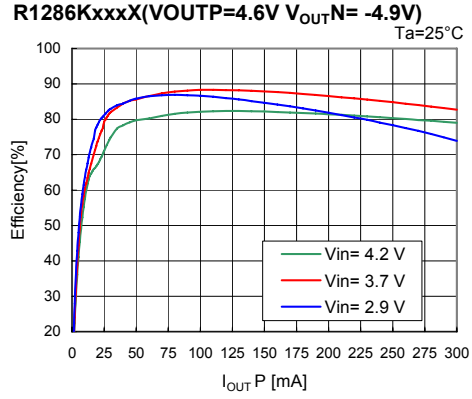


R1286KxxxX(V_{OUT}N= -6.0V)

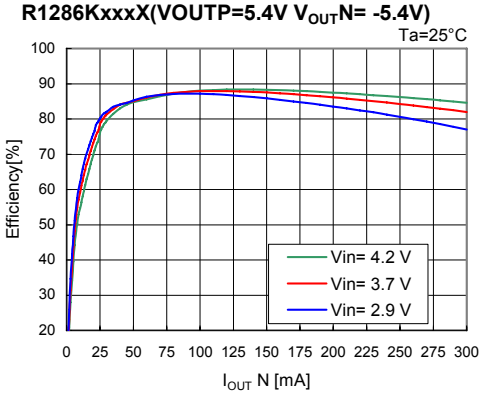


2) Efficiency vs. Output Current

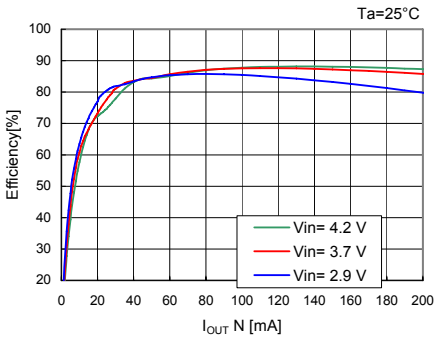
R1286KxxxX(VOUTP=4.6V V_{OUT}N= -4.9V)



R1286KxxxX(VOUTP=5.4V V_{OUT}N= -5.4V)

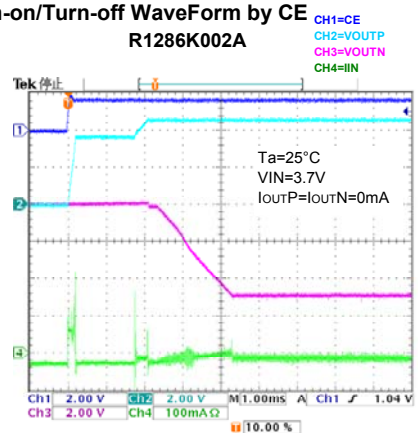


R1286KxxxX(VOUTP=5.8V V_{OUT}N= -6.0V)



3) Turn-on/Turn-off WaveForm by CE

R1286K002A



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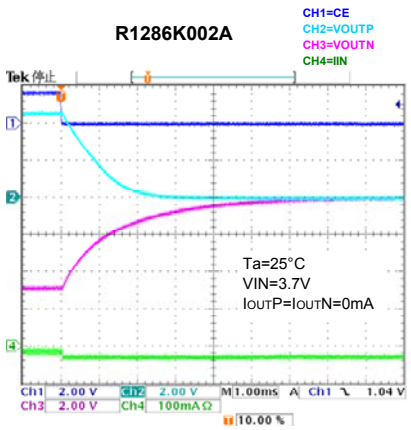

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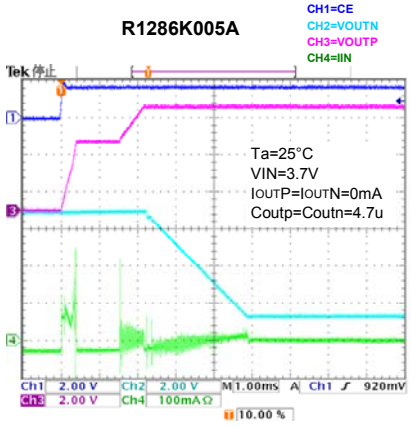

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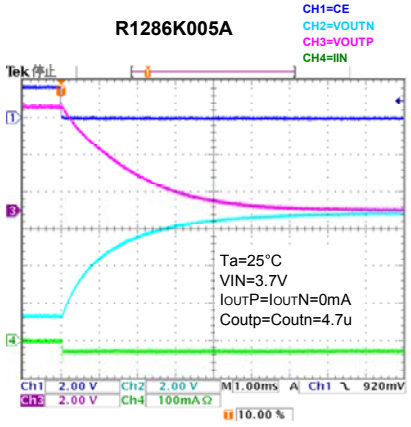

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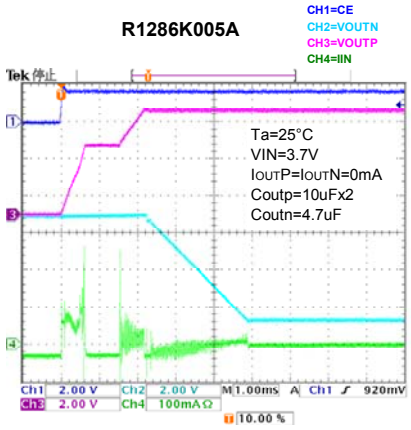

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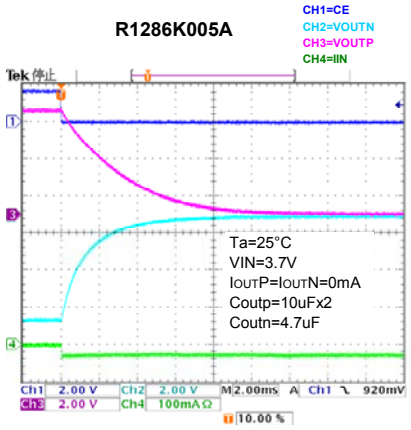
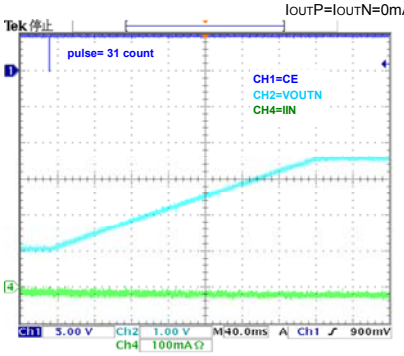
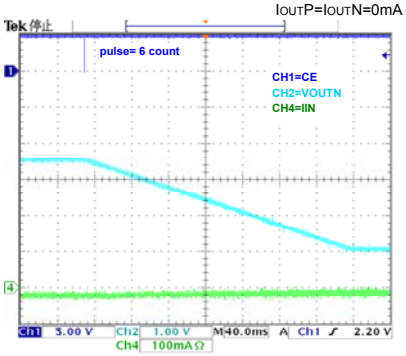


4) VOUTN WaveForm with S-Wire control

R1286K002A(-4.9V to -2.4V) Ta=25°C IOUTP=IOUTN=0mA

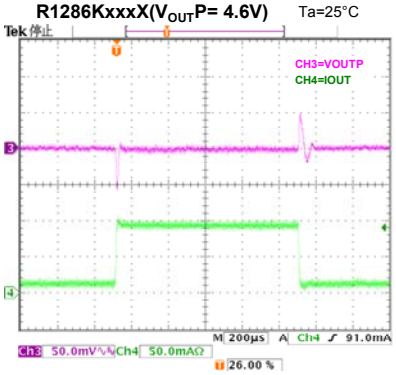


R1286K002A(-2.4V to -4.9V) Ta=25°C IOUTP=IOUTN=0mA

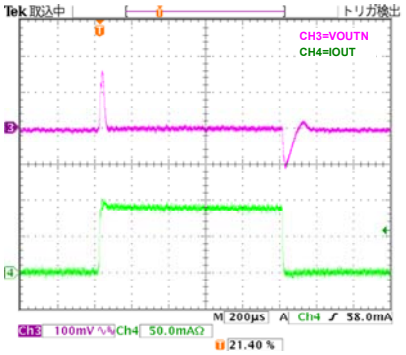


5) Load Transient Response

R1286KxxxX(V_{OUT}P= 4.6V) Ta=25°C

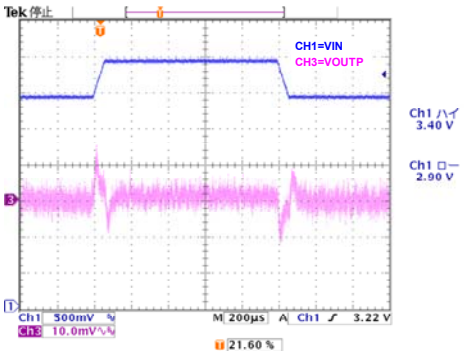


R1286KxxxX(V_{OUT}N= -4.9V) Ta=25°C

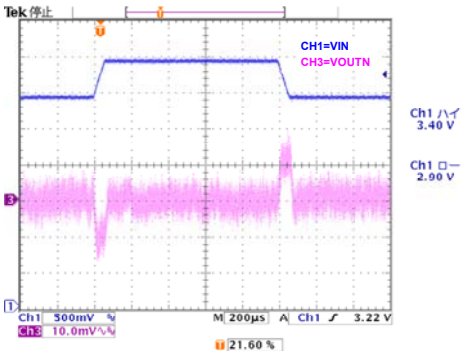


6) Line Transient Response

R1286KxxxX(V_{OUT}P= 4.6V) Ta=25°C IOUTP=100mA

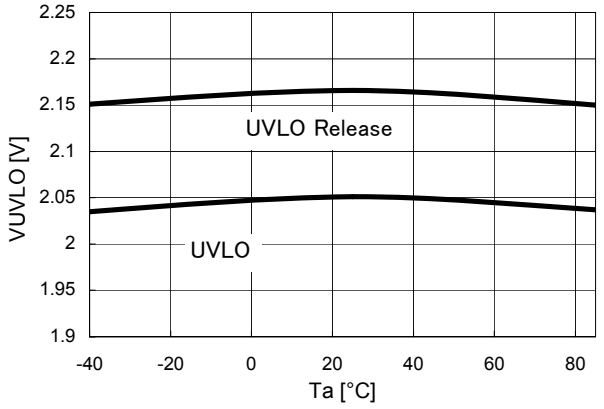


R1286KxxxX(V_{OUT}N= -4.9V) Ta=25°C IOUTN=100mA



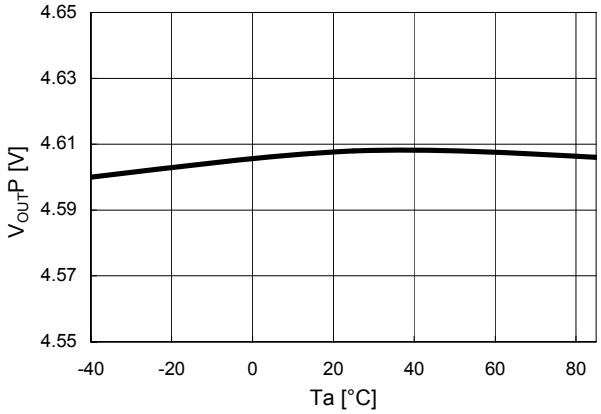
7) UVLO Voltage VS. Temperature

R1286KxxxX



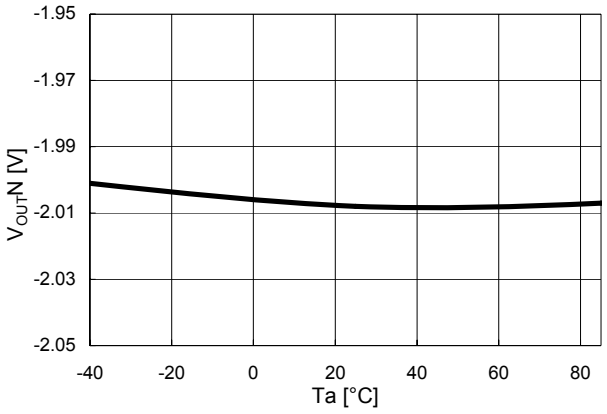
8) VOUTP Voltage VS. Temperature

R1286K002X

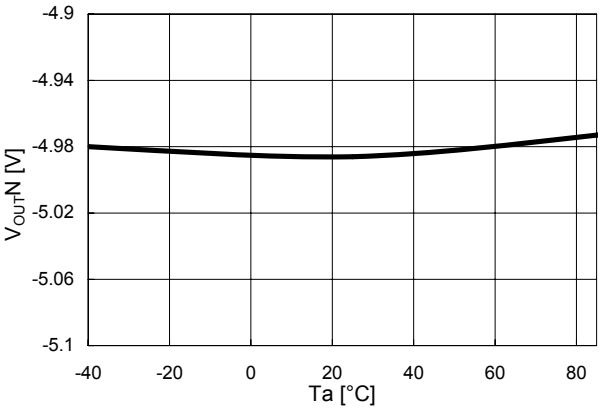


9) VOUTN Voltage VS. Temperature

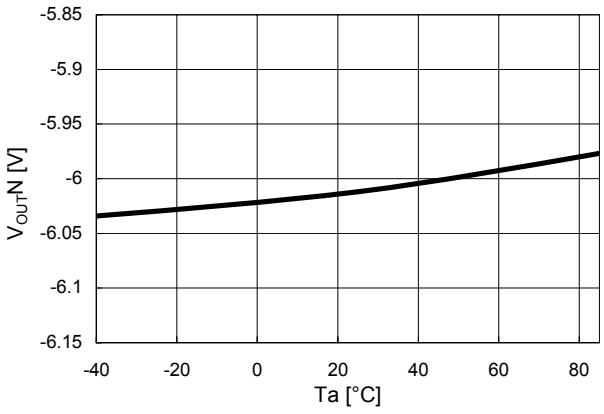
R1286KxxxC



R1286KxxxX

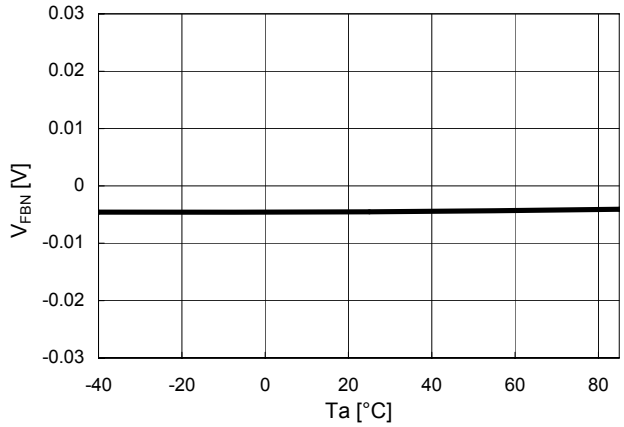


R1286KxxxG



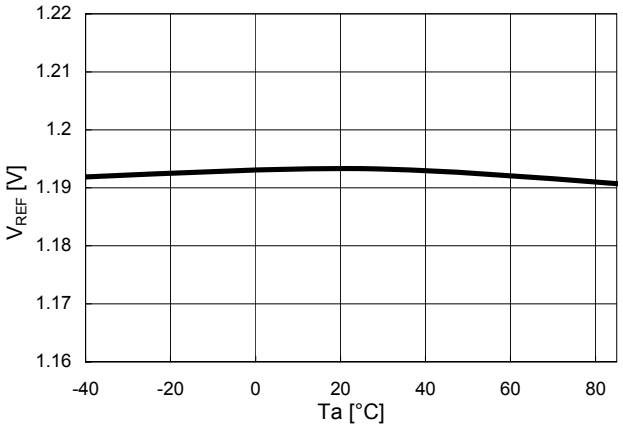
10) V_{FBN} Voltage VS. Temperature

R1286K001B



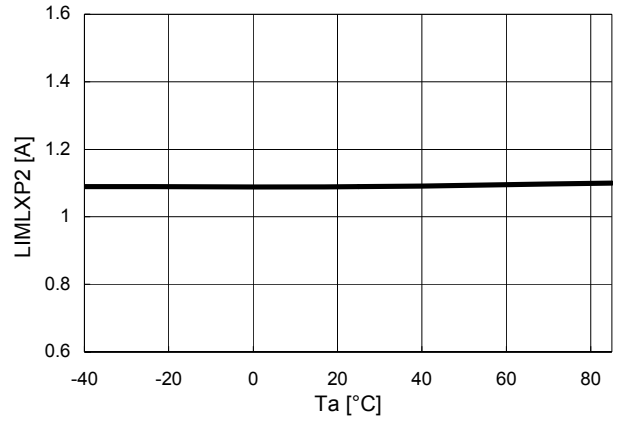
11) V_{REF} Voltage VS. Temperature

R1286K001B



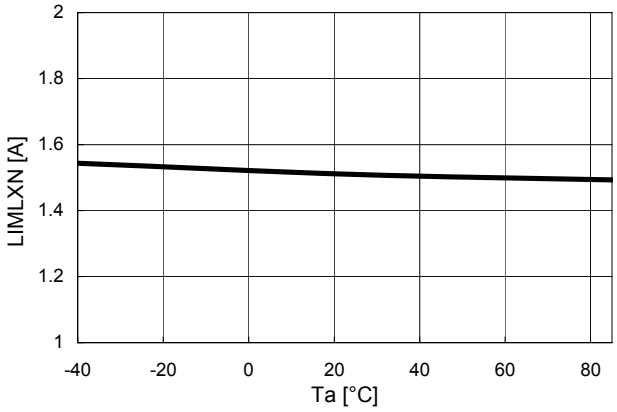
12) L_{XP} Current Limit VS. Temperature

R1286KxxxX



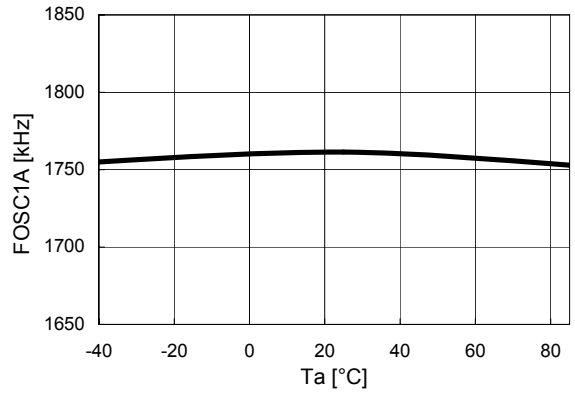
13) L_{XN} Current Limit VS. Temperature

R1286KxxxX



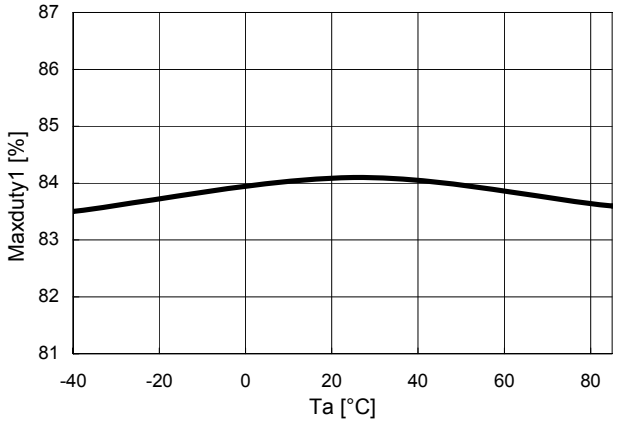
14) Oscillator Frequency VS. Temperature

R1286KxxxX



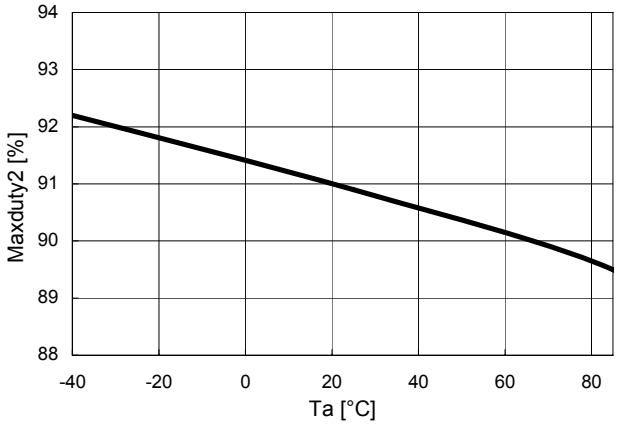
15) Maxduty1 VS. Temperature

R1286KxxxX



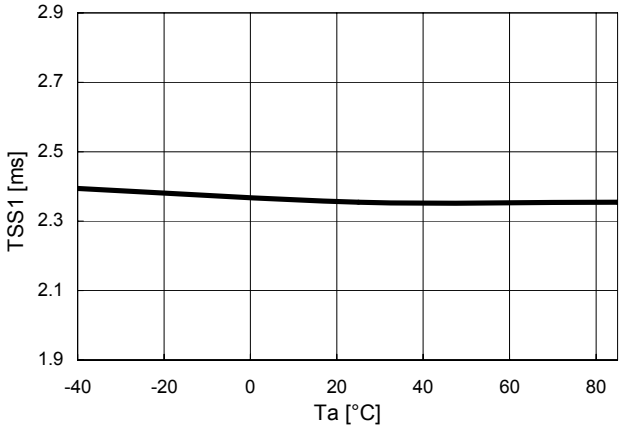
16) Maxduty2 VS. Temperature

R1286KxxxX



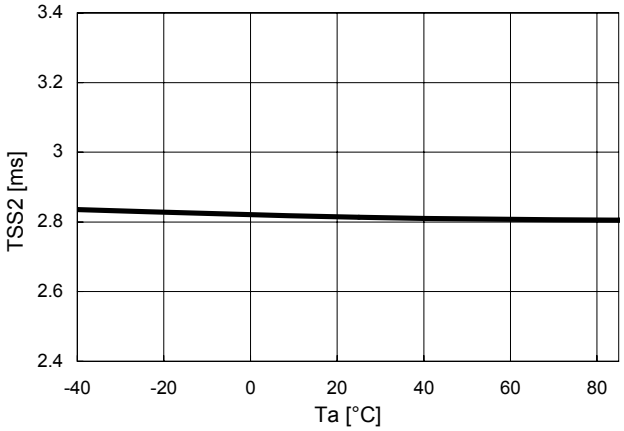
17) CH1 Soft-Start Time VS. Temperature

R1286KxxxX



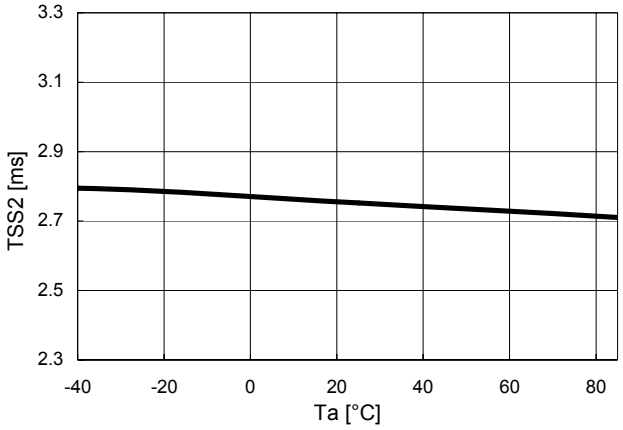
18) CH2 Soft-Start Time VS. Temperature

R1286KxxxG



19) CH2 Soft-Start Time VS. Temperature

R1286K001B



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5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death (aircraft, spacevehicle, nuclear reactor control system, traffic control system, automotive and transportation equipment, combustion equipment, safety devices, life support system etc.) should first contact us.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, firecontainment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. Anti-radiation design is not implemented in the products described in this document.
8. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RICOH COMPANY., LTD. Electronic Devices Company

■Ricoh presented with the Japan Management Quality Award for 1999.
Ricoh continually strives to promote customer satisfaction, and shares the achievements of its management quality improvement program with people and society.

■Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

RoHS Compliant
Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.

http://www.ricoh.com/LSI/

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